

January 31, 2005

DECLARATION

The undersigned, Jan McLin Clayberg, having an office at 5316 Little Falls Road, Arlington, VA 22207-1522, hereby states that she is well acquainted with both the English and German languages and that the attached is a true translation to the best of her knowledge and ability of international patent application PCT/DE 03/03390 of Eschler, J., et al., entitled "HEADLIGHT FOR VEHICLES".

The undersigned further declares that the above statement is true; and further, that this statement was made with the knowledge that willful false statements and the like so made are punishable by fine or imprisonment, or both, under Section 1001 of Title 18 of the United States Code and that such willful false statements may jeopardize the validity of the application or document or any patent resulting therefrom.

  
Jan McLin Clayberg

HEADLIGHT FOR VEHICLES

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Prior Art

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The invention relates to a headlight for vehicles that emits light in the near-infrared range and that has both a light source, which projects not only in the infrared range but also in the visible range, and an infrared range- transmissive filter.

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From German Patent DE 40 32 927 C2, for improving night vision, it is known to illuminate the space ahead of the vehicle with infrared radiation and to capture the thus- illuminated region with a camera. For this purpose, the near- infrared range is used, since suitable image sensors for it are available. However, the light sources used for the purpose have a radiation maximum in the near-infrared range.

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In the known headlights, filtering which prevents visible light from being emitted is therefore provided for the illumination in the near-infrared range. Because of the possibility of confusion with taillights, headlights at the front of the vehicle that give a red impression must be avoided, which as a rule is also regulated by law, through relevant regulations.

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The object of the present invention is to propose a headlight for emitting radiation in the near-infrared range that utilizes the sensitivity of image sensors as well as possible and does not produce a red color impression.

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Advantages of the Invention

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This object is attained according to the invention in that a transition range of the filter extends from the infrared range into the red spectral range of the visible

range; and that further spectral components in the visible range are emitted in attenuated form.

The headlight of the invention has the advantage that the intensity of the  
5 infrared range, in the particular spectral range in which the image sensor is still relatively highly sensitive, is largely unattenuated by the filter, and that nevertheless, the headlights do not produce a red color impression. Filters that do not have extremely steep edges and that are therefore not correspondingly expensive can be used. Interference filters are preferably suitable.

10 The embodiments of the invention in detail and their refinements depend, among other factors, on the extent to which the filter admits visible light in the red spectral range, and on what demands are made in terms of the color and radiation output of the total visible light admitted. In an advantageous embodiment of the  
15 invention, it is therefore provided that the further spectral components and the red component admitted by the filter produce a color impression which is not red.

Another advantageous refinement of the invention is that the filter is transmissive for the further spectral components.

20 With this refinement, although the red component cannot be compensated for, nevertheless the further spectral components can predominate, in such a way that the radiation admitted by the filter, of between 700  $\mu\text{m}$  and 780  $\mu\text{m}$ , is not perceived as red by the human eye. This refinement can be designed such that  
25 the further spectral components and the red component include the visible range. It is preferably provided that the transmission of the filter is greater in the short-wave range of the further spectral components than in their long-wave range.

To illuminate a distant light region with the aid of infrared radiation, so-called

projection headlights, in which as in a projector a parabolic mirror and a lens are provided as an objective, are particularly suitable. In one embodiment of such a headlight, known from Japanese Patent Disclosure JP-2000348513 A, the filter is provided between the parabolic mirror and the lens. There, however, because of the wide opening angle of the beam path, various transmission angles occur, which causes the filter characteristic curve to shift into the peripheral regions of the beam path, rather than the middle.

To avoid this disadvantage, in another refinement of the headlight of the invention, it is provided that the filter is located in front of the headlight. At that point, the peripheral and middle rays of the entire beam are virtually parallel.

Another refinement makes an especially small filter possible by providing that the filter is disposed on a diaphragm located between the light source and the lens.

An advantageous feature of the invention provides that a diaphragm is disposed between the light source and the lens. As a result, an advantageous shape can be given to the emerging cone of radiation. It may also be provided that the filter is disposed on the diaphragm.

In this advantageous feature, the illuminated area can be adapted to the field of view of an infrared image sensor, mounted at a variable height, by providing that the diaphragm has a trapezoidal opening.

#### Brief Description of the Drawing

Exemplary embodiments of the invention are shown in several figures in the drawing and explained in further detail in the ensuing description. Shown are:

Fig. 1, schematically, the illustration of a first exemplary embodiment;

Fig.2 , a second exemplary embodiment, and

Fig. 3, a third exemplary embodiment of a headlight of the invention;

Fig. 4, a different view of the second exemplary embodiment;

Fig. 5, various characteristic curves for explaining the invention; and

Fig. 6, an exemplary embodiment of a filter characteristic curve.

#### Description of the Exemplary Embodiments

Figs. 1 and 2 show the essential parts of a headlight, which is embodied as a so-called projection headlight. A halogen incandescent bulb 1 is located in a reflector 2 in such a way that radiation 5 that is tightly focused by the lens 4 emerges from the headlight. A filter 6 admits radiation in the near-infrared range, while visible light is meant to be suppressed by the filter 6.

In the exemplary embodiment of Figs. 2 and 4, a diaphragm 7 is located at 3 and has an opening 8 which has the form of a trapezoid, providing a corresponding boundary for illumination of the space ahead of the vehicle that is adapted to the field of view of an infrared image sensor mounted at a variable height.

The exemplary embodiment of Fig. 3 has a filter 6' disposed in the opening in the diaphragm 7. This has the advantage that the filter 6' can be made smaller

than the filter 6 (Fig. 2).

Fig. 5 shows various characteristic curves, whose explanation contributes to understanding the invention. Specifically, as a function of the wavelength  $\lambda$ , relative values for the sensitivity 11 of the human eye, the sensitivity 12 of a conventional image sensor, the spectral distribution 13 of a light from a halogen incandescent bulb, and a filter characteristic curve 14 are shown. Ideally, the filter characteristic curve 14 has an extremely steep edge 15.

The quality of the signal shown on a screen is determined, among other factors, by the intensity of the incandescent bulb, the sensitivity of the image sensor, and the transmission of the filter. Because of the maximum sensitivity of the image sensor for visible radiation, IR headlights are meant to emit an infrared range that as much as possible is near the visible range. However, this is limited by the fact that lights that appear red are prohibited by law on the front of the vehicle. Moreover, filters with a very steep edge 15 are complicated to manufacture and are correspondingly expensive.

Fig. 6 shows the characteristic curve of a filter which in the total visible range has a transmission that, although slight, is still perceptible, and that is elevated somewhat in the shorter-wave range.

A filter with this kind of characteristic curve can be realized for instance as an optical interference filter with from 40 to 70 coatings that are applied to a glass or plastic substrate. The coatings may be applied to only one side or maybe distributed over both sides. It is also possible for a plurality of substrates, preferably two, to be used. The transmission for wavelengths between 400 nm and 710 nm amounts to less than 1%. For wavelengths between 780 nm and 1100 nm, the transmission is between 80% and 100%, in each case with transmission

directions perpendicular to the surface of the filter. The rise at the edge (transition range) of the filter (transmission of from 10% to 90% of the maximum value) occurs within a range of less than 40 nm.